

US NAVY FY 1997 RESEARCH PROGRAM

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LONG-TERM GOALS

The National Center for Physical Acoustics (NCPA) provides an integrated physical acoustics laboratory to facilitate research in sound propagation and attenuation, molecular and chemical physics, and underwater acoustics. By integrating the needs of different funding agencies, NCPA can provide a critical mass of resources to tackle selected problems of interest to the Navy. These include the effects of bubbles on propagation under water (and of atmospheric turbulence), sound propagation in saturated sediments (and in soils on the earth's surface), as well as more basic physics of sound useful to Navy applications.

RESEARCH COMPONENTS

Graduate Fellowships (PI: Henry E. Bass)

NCPA has offered fellowships to outstanding students since 1991. Current NCPA fellows are: a) Michael McPherson, who should receive his Ph.D. in 1998 in the field of Solid State Acoustics; b) Michael Oelze who successfully passed the comprehensive exams, should graduate in 1998 and is working in sediments; and c) Wayne Prather who successfully passed comprehensive exams and is working on nonlinear acoustics. The new funding method for NCPA does not include support for NCPA fellows; there are sufficient funds available to support present students until their graduation.

Parametric Excitation of a Resonant Acoustic Mode (PI: Bruce Denardo)

A double-cavity Helmholtz resonator with a U-shaped neck was built so that the neck length can be modulated in a manner similar to a trombone slide. An electrodynamic shaker drives the neck. Because the natural frequency of a Helmholtz mode depends upon the neck length, parametric excitation will occur if the drive amplitude exceeds a threshold that is inversely proportional to the quality factor Q , and could lead to very large response amplitudes. Experiments revealed that the threshold was unattainable because the turbulence due to the movement of the neck lowered Q to the extent that the drive was incapable of exceeding the threshold. A double-cavity Helmholtz resonator whose cavity volumes are modulated is being constructed. Pistons driven by a dc motor will be employed.

Investigations of Solitons (PI: Bruce Denardo)

Theoretical work on the existence of breather and kink solitons in sandstone was concluded. New solitons based on a nonanalytic nonlinearity, which models finite-amplitude sound in sandstone, were discovered. A presentation was given at an Acoustical Society of America meeting, and a manuscript has been submitted to the *Journal of the Acoustical Society of America* (JASA). Experimental attempts to generate and observe breather solitons in a bar of sandstone are being conducted. In other soliton research, an experiment with surface waves on a liquid in a vertically-oscillated annular

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channel was set up. A new form of localized kink wave was observed to permanently exist for a range of drive amplitude and frequency, and to temporarily exist during the hopping from one extended mode to another. The hopping is currently being imaged.

Investigations of Linear and Nonlinear Acoustic Noise (PI: Bruce Denardo)

A successful experiment was performed on an acoustical analogy of the Casimir effect. The experiment involved two plates in an externally-generated, band-limited noise field. The data confirmed a surprising theoretical calculation that the lower band limit of the noise can cause the force to be repulsive. Manuscripts on this work were submitted to *Physical Review Letters* and JASA. In other work, numerical simulations of the absorption of sound by shockless noise were successfully performed, and found to be sensitive to the degree to which the noise is Gaussian. A presentation on this subject was given at an Acoustical Society of America (ASA) meeting by a student who recently graduated with an M.S. degree. A manuscript for refereed publication is currently being prepared.

Experimental Investigation of Shape Stability and Mass Transport in Gas Bubbles Oscillating at High Amplitudes (PI: D. Felipe Gaitan)

This effort investigates the new mass diffusion mechanism responsible for stable, large amplitude, acoustically driven single-bubble oscillations by changing two important parameters: surface motion and dissolved gas concentration. Construction has begun on the apparatus to measure shape instability and rectified diffusion thresholds. Two critical areas that need improvement were identified: the recording and storage of images, and the gas/liquid handling apparatus. Off-the-shelf video camera lenses have proven inadequate for attaining resolutions on the order of 1 μ m. Hence, a pinhole-collimating lens arrangement is being considered. This technique is similar to the one used in confocal microscopes. However, the light source has to be pulsed in order to freeze the bubble motion. This and the fact that the pinhole cuts much of the light means that very little light will be available for imaging. Since close proximity to the bubble will increase the light, small, rectangular levitation cells are being tested for that purpose. The gas/liquid handling apparatus is currently being updated to handle different gases and colder ambient temperatures. A graduate student was hired to reduce and analyze previously obtained data on bubble instability pressure-amplitude thresholds. These data will be useful in understanding bubble dynamics at large amplitudes.

Bubble-Related Ambient Noise in the Ocean (PI: Ali R. Kolaini)

This effort studies the noise generation from laboratory breaking waves, turbulent/bubble interaction and high-frequency scattering from an artificial bubble cloud as well as bubble clouds generated by breaking waves. Models that explain some of these bubble-related noise mechanisms were developed and verified. As a result, five manuscripts for refereed publication are currently in preparation.

Bubble Related Ambient Noise from the Surface Zone (PI: Ali R. Kolaini)

This effort is related to the ambient noise measurements in the EXP97" experiment conducted off the Scripps Institution of Oceanography Pier. The ambient noise data were recorded in the surf zone and just beyond the surf zone in the Spring 1997. Data is being analyzed to examine if the ambient sound field in the surf zone can be used to a) ascertain the role of low- and high-frequency noise mechanisms, b) identify a single breaker event to investigate the mean ambient bubble field, and c) investigate the low-frequency sound propagation losses.

Acoustic Properties of Gassy, Unconsolidated Sediments (PI: James Sabatier)

The effect of water vapor on the acoustic properties of unconsolidated sediment materials, Ottawa sand and spherical glass beads, were studied. Measurements were made of the compressional and shear wave velocities as a function of very low moisture content, typically less than 0.2% pore volume saturation. A physical model will be developed that will describe the acoustic relaxation at the points of grain contact due to fluid flowing in and out of the contact area. The effects of moisture on the acoustic properties of glass beads is dramatic, primarily explained by the formation of highly viscous hydrogels at the grain contacts. Moisture effects in Ottawa sand result in a zero tangential stiffness which dominates the gravitational loading effect observed in the dry material. This effort has resulted in one paper accepted for publication in JASA and 3 presentations given at ASA meetings.

Resonant Ultrasound Spectroscopy (PI: Henry E. Bass)

ONR has awarded NCPA a separate grant supporting hire of senior researchers in Resonant Ultrasound Spectroscopy (RUS). With University approval, funds allocated for RUS under the current grant were frozen pending transition to the new funding. Dr. Bass will recommend expenditures from the current grant to assist scientists formerly supported by earmarked funds in their transition to standard contract and grant mechanisms.